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# THE PLANT DISEASE REPORTER

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## THE PLANT DISEASE SURVEY

Division of Mycology and Disease Survey

BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING

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DIVISION OF MYCOLOGY AND DISEASE SURVEY

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# THE BURROWING NEMATODE AND OTHER PARASITIC NEMATODES IN RELATION TO SPREADING DECLINE OF CITRUS[1]

R. F. Suit and E. P. DuCharme

Spreading decline disease of citrus trees in Florida appears to be the result of infestation of the feeder roots by the burrowing nematode (Radopholus similis (Cobb) Thorne)[2]. The first case of spreading decline was found in the Lucerne Park area of Polk County before 1930. Today it is known to occur in 152 groves. The majority of these are located in Polk County, with others in Highlands, Orange, Lake and Hillsborough Counties. A typical diseased area consists of a group of trees that are stunted and have fewer and smaller leaves, reduced yield, and a lack of feeder roots. Such trees wilt much more readily than healthy trees during dry periods. Trees with spreading decline have been known to remain in an unthrifty condition for over 20 years, but they do not die unless neglected. A decline area may appear at any point in the grove and thereafter spreads in all directions.

Investigations into the nature, cause, and control of spreading decline were started in 1945. It was found that the disease usually spreads through a grove at the rate of one or two trees on the margin each year. Such spread occurs up hill or down; without regard to direction of cultivation; under paved, clay, or sand roads and railroad tracks where the distance between trees is less than 100 feet; and into adjacent groves. In extensive research work, no experimental evidence was obtained to indicate that spreading decline was the result of either a nutritional deficiency, a soil toxin, a virus disease, or a fungus disease (6, 7, 8, 9, 10). The deterioration of the feeder root system in spreading decline plus some other characteristics suggested the possibility of nematode infestation and work on nematodes was included in the investigation.

In 1947 the citrus nematode, Tylenchulus semipenetrans Cobb, was reported as being found associated with spreading decline in some groves (7). Subsequent investigation (10) showed that this nematode was not the causal factor in spreading decline.

Although the citrus nematode had been eliminated as the cause of spreading decline, there was much evidence that another nematode might be involved. On this basis, experiments were started on the use of soil fumigants prior to replanting as early as 1948. The favorable responses in these experiments gave further corroborative evidence. Later a study of the nematode population in decline and healthy areas in 50 groves showed a significantly higher population in the decline areas as compared to the healthy areas.

In the process of this work, a number of plant parasitic nematodes not hitherto reported on citrus, and some which had been reported associated with citrus in other areas though not in Florida, were discovered. The difficulty lay in the determination of the particular nematode that was the cause of the decline. One of these, the burrowing nematode, Radopholus similis, not hitherto reported on citrus, was established as the probable cause. A report on the work with the burrowing nematode and a listing of other new nematodes on Florida citrus is given below.

## THE BURROWING NEMATODE

Earlier work having been unproductive, root observation boxes were placed in both healthy and decline areas to study the relative feeder root development in the two areas. The boxes were in place in August of 1951. On September 7 a new flush of feeder roots was observed in the decline area. By October 15 brown regions were observed on the feeder roots. By December 7 all the visible feeder roots were in advanced stages of decay. Root growth in the healthy area was evident by September 17 and no decay of the new feeder roots was noted by December 7, 1951. These results were confirmed by growing sour orange seedlings in decline and healthy soil in small root observation boxes in the greenhouse during the winter.

Subsequent research on the citrus feeder root distribution of mature trees, by Ford (3), showed that in trees with spreading decline there were usually no feeder roots in the soil below a depth of 30 inches though the larger secondary roots were present. During periods of active root growth, feeder roots were found developing below this depth, but died out in less than a month. In general, it has been found that a diseased tree has about half as many feeder roots

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[1]Florida Agricultural Experiment Station Journal Series, No. 166.

[2]The writers wish to acknowledge the assistance of Dr. J. R. Christie, Senior Nematologist, Division of Nematology, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, in the identification of the various nematodes.

as a corresponding healthy tree. It is also apparent that the greatest loss of feeder roots is in the lower depths, where feeder roots are absent except for short periods. Feeder-root development in the top foot of soil is not greatly different between diseased and healthy trees.

The progress of the work had always been handicapped by the difficulty of reproducing the disease in pots. In studies involving the growth of citrus seedlings in pots, using soil from decline and healthy areas, no apparent differences were noted unless the pots were buried in the soil outside of the greenhouse. The discovery that the destruction of the feeder roots of mature trees occurred chiefly below 2 feet suggested that the soil temperature had some influence on the causal factor of spreading decline and that in pot experiments on greenhouse benches the soil temperature was too high. Thermograph records showed that the maximum temperature in the soil at a depth of 3 feet during the summer was 79°F., while at 6 inches it was 103°F. The indications were that the high temperatures near the surface might be a limiting factor.

To investigate this question, two soil temperature tanks were constructed in which the temperature of the soil in pots could be controlled at 74° to 78°F. Topsoil (0 to 6 inches) and subsoil (24 to 30 inches) samples were obtained from the spreading decline and healthy areas of each of four groves and placed in 5-quart cans in the temperature control tank, five cans being set up for each sample. Sour orange seedlings were planted in the cans August 8, 1952. During this experiment the plants were fertilized each month and watered as necessary. Within six weeks after the seedlings were planted it was apparent that none in the decline subsoil were making normal growth.

The experiment was continued until March 30, 1953, when seedlings growing in the decline subsoil were much smaller than those growing in the corresponding healthy subsoil. This difference was consistent for all four groves. Figures 1 and 2 show the differences in top and root growth, respectively. In comparison, there was no apparent difference between the seedlings grown in the topsoil from the decline and healthy areas. This was the first time it had been possible to produce symptoms of spreading decline consistently under experimental conditions.

The discovery of the brown regions on feeder roots associated with decline in the root observation boxes in both the field and greenhouse plus the finding of a larger total nematode population in spreading decline as compared to healthy areas indicated that the browning might be caused by a nematode. Accordingly, feeder roots from trees in the diseased and healthy areas of 11 groves were examined and dissected. In all cases characteristic lesions were found on the feeder roots from the spreading decline trees and not from the healthy trees. These lesions usually occurred on roots less than 1/16 inch in diameter. Often the location of a lesion or cavity was recognized only by the presence of a small split or hole in the epidermis. Because of the small size of the lesions, the work had to be done with the aid of a dissecting microscope at a magnification of 45x.

The burrowing nematode, R. similis, which is about 1/50 inch long, was found in such lesions, in numbers ranging from 1 to 25 depending on the age and size of the lesion. These lesions initiated the brown regions already mentioned. Further investigation revealed the burrowing nematode in lesions and cavities on feeder roots at depths as great as 12 feet.

A study of the nematodes infesting the feeder roots of the sour orange seedlings in the temperature-control experiment previously discussed was then made. This study showed that R. similis, the burrowing nematode, was the only parasitic nematode associated with plants showing symptoms of spreading decline in the cans. This nematode was found on all of the plants growing in subsoil from the decline area of all four groves studied. This constitutes strong evidence that the burrowing nematode is the causal agent in the decline.

Investigations were initiated to determine if the burrowing nematode was present in all of the groves showing spreading decline. To date, 29 affected groves have been examined. R. similis was found in the diseased area and not in the healthy area in 28 of these groves, and has not been found in any of the 26 healthy groves examined. The one failure to find the nematode in association with the disease does not detract from the evidence, since sampling is difficult and frequently several samplings are necessary before the burrowing nematode is found. Its existence in cavities in the rootlet does not permit ready determination with the sampling methods used for migratory nematodes.

The burrowing nematode occurs in tropical and sub-tropical regions of the world and was first identified by Cobb in 1893 (4). It is known to attack the roots of the following plants: pineapple, sugarcane, tea, coffee, banana, bamboo, nut grass, edible canna, pigeon pea, and sweetpotato. The nematode attacks the roots of citrus in the same manner as it does roots of these plants, causing lesions and cavities in which it feeds and lives. When the infested rootlets decay the nematodes move to uninfested roots (2, 4, 5).

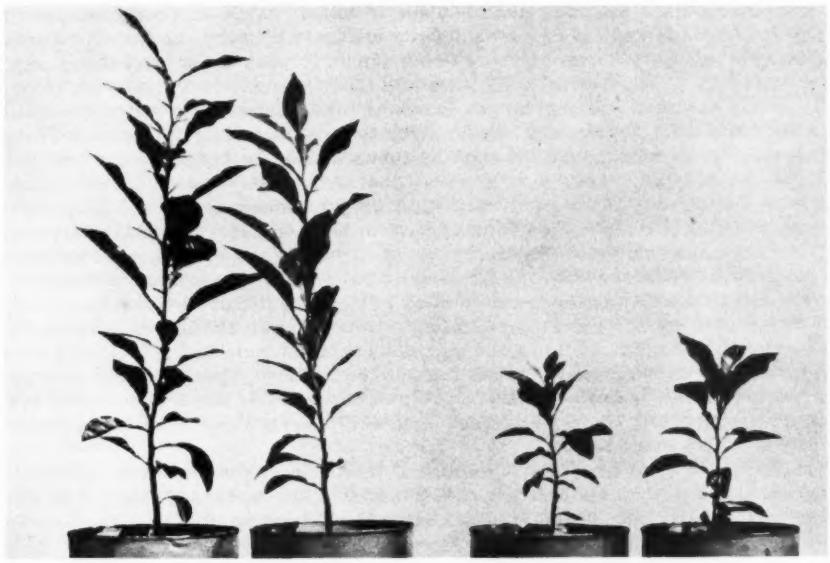

FIGURE 1. Growth of sour orange seedlings in cans of subsoil from the healthy area, left, and the spreading decline area, right, of Grove S. (Temperature control experiment).

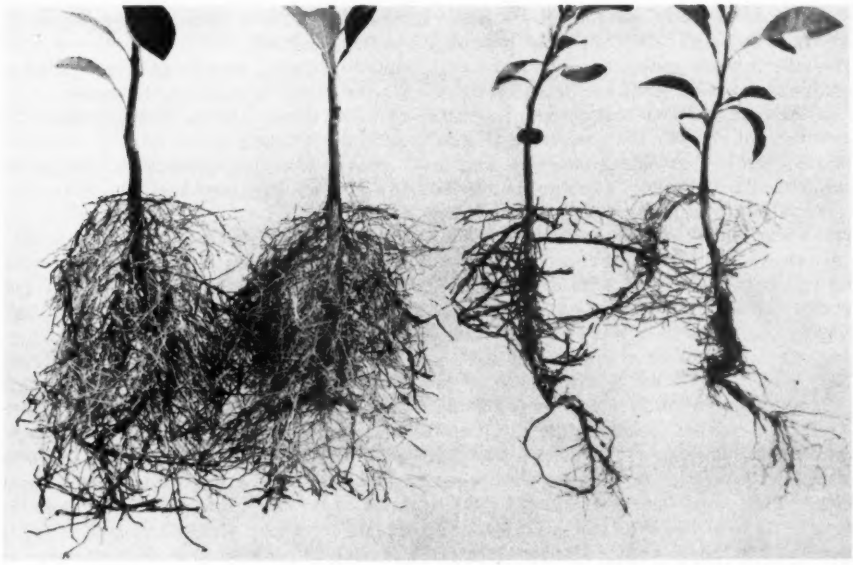

FIGURE 2. Deterioration of the root system of sour orange seedlings caused by the burrowing nematode. Root systems of the test plants in Fig. 1. Healthy, left and infested, right.

This is the first report of the natural occurrence under field conditions of Radopholus similis in Florida and the first time that this nematode has ever been reported infesting and causing extensive damage to citrus feeder roots. In this study, so far, R. similis has been found causing injury to feeder roots of rough lemon (Citrus limon (L.) Burmann), sour orange (C. aurantium L.), sweet orange (C. sinensis (L.) Osbeck), and grapefruit (C. paradisi MacFad.). It has not been possible as yet to examine the mandarin group, C. reticulata, for the burrowing nematode, but results of earlier greenhouse experiments have indicated that it is probably subject to attack. The variety of citrus budded on the rootstock has no apparent influence on the disease.

Field experiments on the control of spreading decline have been in progress since 1948. Preliminary results from some of the experiments have indicated that the treatment of the soil with D-D soil fumigant, following the removal of the diseased trees, will be beneficial. However, no definite recommendations for the control of this disease can be made at this time. Since the nematodes have been found as deep as 12 feet, a thorough fumigation which will kill all the nematodes will be extremely difficult. Work on soil fumigants is being intensified.

The obvious solution would be the use of a resistant rootstock. The only favorable start so far toward the development of resistance is the finding of one tree that has escaped the disease in each of three different decline areas. The stocks of these three trees are being propagated for further study. A large number of miscellaneous rootstocks not commonly used commercially are also being tested.

The finding of a control for a nematode of this type will not be easy. Little is known concerning either its host range or its susceptibility to chemical treatment. The depth to which it occurs will certainly increase the difficulty of soil treatment.

## OTHER PARASITIC NEMATODES FOUND ASSOCIATED WITH CITRUS FEEDER ROOTS

In addition to the burrowing nematode, many other kinds of nematodes were observed in association with citrus feeder roots in the samples obtained from numerous groves. Among the general groups of nematodes commonly found were the Dorylaimidae, but the majority of these are not known to be parasitic. Besides these and the burrowing nematode, R. similis, eight other plant-parasitic nematodes were found in many instances to be associated with citrus feeder roots in Florida. These are discussed briefly below:

The citrus nematode, Tylenchulus semipenetrans Cobb, was first found by Thomas (11) in California and was first reported on citrus feeder roots in Florida by Byars, 1913 (1). It feeds on the citrus roots and causes a decline of weak trees. Since 1947, a total of 209 groves have been examined for the presence of this nematode. It was found in only seven out of 77 groves affected by spreading decline, and in 17 groves showing another type of decline. It was also found in 12 out of 115 apparently healthy groves. As previously mentioned (10), the citrus nematode is not the cause of spreading decline.

The sting nematode, Belonolaimus gracilis Steiner, damages the roots of pines, vegetables, some grasses, and strawberries in Florida. Recently the sting nematode was reported as causing possible damage to citrus roots in Florida by V. G. Perry and J. R. Christie (unpublished). In the investigations herein reported, 68 groves were examined for the presence of the sting nematode. It was found in nine out of 39 spreading decline areas and in 14 out of 29 groves that did not have spreading decline. In two groves with spreading decline, the sting nematode was found in the healthy area of the grove and not in the diseased area, while in another grove this nematode was present in both areas. These results would indicate that B. gracilis is not related to spreading decline, although it may be a factor in other types of decline.

Aphelenchus avenae Bastian is a facultative parasite and may feed on the roots of plants or on fungi in the soil. A. avenae was found by Goodey (4) in a sample of citrus roots from Rhodesia. This nematode was found by the authors to be associated with citrus feeder roots in 25 groves. Apparently it is not a factor in spreading decline, since it was present in both the diseased and healthy areas in the same grove and also in healthy groves free from decline. This is the first time that this nematode has been reported as associated with citrus roots in the United States.

Hoplolaimus coronatus Cobb has been found associated with the roots of pine seedlings in Florida by Steiner (2), and has been reported from the roots of sugarcane, corn, alfalfa, and red clover (2). The authors found it associated with citrus feeder roots in both the spreading decline and healthy areas in two groves, in six groves in the decline area only, and in one grove in the healthy areas only. This nematode also was found in eight healthy groves. This is the

first report of association of H. coronatus with citrus feeder roots.

The meadow nematode, Pratylenchus pratensis (de Man) Filipjev, has been reported associated with citrus roots in California (12) and in Brazil (2). This nematode was found in two groves in the spreading decline area only, and in seven groves in the healthy area only. In addition, it was found in two healthy groves. This is the first report of association of P. pratensis with citrus feeder roots in Florida.

The stubby-root nematode (Trichodorus sp. Cobb) causes root damage to vegetable crops in Florida. It was recently found associated with citrus feeder roots in Florida by V. G. Perry and J. R. Christie. During the present work, the stubby-root nematode was found in eight groves in the spreading decline area only, in two groves in both decline and healthy areas, and in two groves in the healthy area only. In addition, it was found in five healthy groves.

The dagger nematode, Xiphenema americanum Cobb, has occasionally been found associated with citrus roots in Texas by W. H. Reynolds in 1952 (unpublished). It was found by the authors in the decline area in only one grove, in the healthy area in only one grove, and in seven healthy groves. This is the first report of association of X. americanum with citrus feeder roots in Florida.

Hemicycliophora sp. de Man is known to feed on the cortex of the roots of some plants. It was found associated with citrus feeder roots in the spreading decline area in one grove, and in two apparently healthy groves. This is the first report of Hemicycliophora sp. being associated with citrus feeder roots.

As a result of this work, it is concluded that Hoplolaimus coronatus, P. pratensis, Trichodorus sp., X. americanum, and Hemicycliophora sp. probably are not related to spreading decline. Although these nematodes have been found associated with citrus feeder roots, the type and extent of injury has not as yet been determined.

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FLORIDA CITRUS EXPERIMENT STATION, LAKE ALFRED

# EXPERIMENTAL GREENHOUSE HOST RANGE STUDIES OF TWO ROOT-LESION NEMATODES, PRATYLENCHUS VULNUS AND PRATYLENCHUS PENETRANS

Harold J. Jensen

Various root-lesion nematodes belonging to the genus Pratylenchus are frequently reported as serious plant pests. Knowledge of the host range of this genus is increasing and now includes several agricultural crops. Although distribution records of the genus are fragmentary, available information indicates that several species are widespread in this country and probably cosmopolitan. Many investigators share the opinion that root-lesion nematodes will prove to be of more economic importance than the well known root-knot nematodes and are giving increased attention to the former as plant disease problems.

Pratylenchus vulnus is widely distributed in California where it is an important parasite of various trees and vines (1). The same species has been found parasitic on boxwood and other ornamentals in Oregon. Another root-lesion nematode, P. penetrans[1], recently restored as a valid species in the genus by Sher and Allen (3), is widely distributed in Oregon where it has been recovered from the root systems of various bulb and nursery plants. The following data accumulated during the past four years may be useful to others who plan to investigate crop rotation and other cultural practices as possible control measures.

Two soil samples were obtained: (a) soil infested with P. vulnus from the root area of an infected walnut tree in the San Jose area of California, (b) soil containing P. penetrans from a narcissus planting showing severe nematode symptoms in the Gresham area of Oregon. The infested soil was sown with seeds or occasionally planted with bulbs or cuttings of selected test plants. The plants were exposed during a growing period of two and one-half to three months to insure ample time for the completion of a life cycle and reinfection by the subsequent generation.

Wherever possible two replications of five plants each were used in trials involving potential hosts of P. vulnus. The trials of P. penetrans were not replicated but several plants of each tested host were grown in each pot of infested soil. A plant was considered to be a host in these investigations if the nematodes were able to penetrate, develop, and reproduce in the root tissue. It is usually difficult to locate these parasites within the host since the root tissues are opaque and the nematodes are transparent. This difficulty was overcome through the use of a staining technique described by Goodey (2). Properly prepared sections of stained material are useful in locating the nematodes within the host since the nematodes retain a darker stain than the adjacent tissues.

## PLANTS EXPERIMENTALLY INFECTED WITH PRATYLENCHUS VULNUS IN GREENHOUSE TESTS

| Scientific Name | Common Name | Horticultural Variety |
|---|---|---|
| Acacia sp. | Acacia | |
| Brassica oleracea var. capitata | Cabbage | Copenhagen Market |
| Citrus paradisi | Grapefruit (seedling) | |
| Citrus sinensis | Orange (seedling) | |
| Crotalaria juncea | Crotalaria | Sunn Hemp |
| Crotalaria spectabilis | Crotalaria | |
| Cytisus scoparius | Scotch Broom | |
| Fragaria chiloensis var. ananassa | Strawberry | Baron Solemacher |
| Gossypium sp. | Cotton | Acala |
| Juglans nigra | Walnut (seedling) | Black Walnut |
| Lathyrus odoratus | Sweet Pea | |
| Lilium longiflorum | Easter Lily | Croft |
| Lotus corniculatus | Birdsfoot Trefoil | |
| Malus sylvestris | Apple | Winesap |
| Medicago sativa | Alfalfa | |
| Melilotus alba | Sweet Clover | |

[1]Identified by Dr. M. W. Allen, Assistant Nematologist, University of California.

(Plants Experimentally Infected with Pratylenchus vulnus in Greenhouse Tests -- continued)

| | | |
|---|---|---|
| Papaver sp. | Poppy | Shirley American |
| Persea americana | Avocado | |
| Phaseolus vulgaris | Bean | Blackeye |
| Phaseolus vulgaris | Bush Bean | Golden Wax |
| Phaseolus vulgaris | Lima Bean | Westan |
| Phaseolus vulgaris | Lima Bean | Wilbur |
| Pisum sativum | Garden Pea | Hundredfold |
| Ricinus communis | Castor Bean | Ricinus |
| Vicia benghalensis | Purple Vetch | |
| Vicia faba | Broad Bean | |
| Vigna sinensis | Cow Pea | Iron |
| Viola cornuta | Tufted Pansy | |
| Vitis vinifera | Grape | Emperor |

## PLANTS APPARENTLY NOT SUSCEPTIBLE TO INFECTION BY PRATYLENCHUS VULNUS IN GREENHOUSE TESTS

| Scientific Name | Common Name | Horticultural Variety |
|---|---|---|
| Anthirrhinum majus | Snapdragon | Rust Proof Maximum Giant |
| Avena sativa | Oats | Palestine |
| Avena sativa | Oats | Ventura |
| Beta vulgaris | Sugar Beet | |
| Beta vulgaris | Table Beet | Detroit Dark Red |
| Brassica juncea var. crispifolia | Mustard | Giant Southern Curled |
| Brassica napobrassica | Rutabaga | American Purple Top |
| Chrysanthemum carinatum | Chrysanthemum | Carinatum Tricolor |
| Convallaria sp. | Lily of the Valley | |
| Dioscorea sp. | Yam | |
| Helianthus annuus | Sunflower | Russian Huge Golden Pad |
| Hibiscus esculentus | Okra | |
| Hordeum vulgare | Barley | Club Mariout |
| Ipomoea batatas | Sweet Potato | |
| Lactuca sativa | Lettuce | Los Angeles Market |
| Lupinus sp. | Annual Lupine | |
| Nicotiana sp. | Nicotiana | Evening Star |
| Nicotiana sp. | Tobacco | |
| Plantago lanceolata | English Plantain | |
| Raphanus sativus | Radish | Crimson Giant |
| Rumex sp. | Perennial Dock | |
| Saintpaulia ionantha | African Violet | |
| Solanum tuberosum | White Potato | Oregon Russet |
| Trifolium hybridum | Alsike Clover | |
| Trifolium repens var. ladino | Ladino Clover | |
| Zea mays var. rugosa | Sweet Corn | Golden Bantam |

## PLANTS OCCASIONALLY PENETRATED BY PRATYLENCHUS VULNUS IN GREENHOUSE TESTS

| | | |
|---|---|---|
| Arachis hypogaea | Peanut | Virginia Runner |
| Capsicum frutescens | Pepper | |
| Daucus carota var. sativa | Carrot | |
| Lycopersicon esculentum | Tomato | Pearson |

PLANTS EXPERIMENTALLY INFECTED WITH PRATYLENCHUS PENETRANS IN GREENHOUSE TESTS

| Scientific Name | Common Name | Horticultural Variety |
|---|---|---|
| Agropyron cristatum | Crested Wheat Grass | Commercial |
| Agropyron intermedium | Intermediate Wheat Grass | Commercial |
| Agropyron trachycaulum | Slender Wheat Grass | Primar |
| Agropyron trichophorum | Pubescent Wheat Grass | Commercial |
| Alopecurus pratensis | Meadow Foxtail | Commercial |
| Arrhenatherum elatius | Tall Oat Grass | Tualatin |
| Avena sativa | Oat | Victory |
| Bromus inermis | Smooth Brome Grass | Manchar |
| Dactylis glomerata | Orchard Grass | Commercial |
| Elymus canadensis | Canada Wild Rye | Commercial |
| Festuca arundinacea | Tall Fescue | Alta |
| Hordeum vulgare | Barley | Hannchen |
| Hordeum vulgare | Barley | Trebi |
| Lotus corniculatus | Birdsfoot Trefoil | Commercial |
| Lotus corniculatus | Birdsfoot Trefoil | Granger |
| Lotus corniculatus | Birdsfoot Trefoil | So. Ore. Narrow Leaf |
| Medicago sativa | Alfalfa | Grimm |
| Medicago sativa | Alfalfa | Ladak |
| Medicago sativa | Alfalfa | Ranger |
| Medicago sativa | Creeping Alfalfa | Burlingham |
| Medicago sativa | Creeping Alfalfa | Rhizoma |
| Melilotus alba | Sweet Clover | Spanish |
| Phleum pratense | Timothy | Commercial |
| Pisum sativum var. arvense | Field Pea | Austrian Winter |
| Poa pratensis | Kentucky Bluegrass | Commercial |
| Secale cereale | Rye | Abruzzi |
| Trifolium fragiferum | Strawberry Clover | Commercial |
| Trifolium hybridum | Alsike Clover | Commercial |
| Trifolium pratense | Red Clover | Kenland |
| Trifolium repens | White Clover | Commercial |
| Trifolium repens var. ladino | Ladino Clover | Commercial |
| Triticum aestivum | Wheat | Federation |
| Vicia villosa | Hairy Vetch | Commercial |

These data indicate that 29 of 60 different kinds of plants tested were susceptible to P. vulnus. The roots of five of the remaining 31 plants were penetrated occasionally but no eggs were observed in the tissues. Necrosis was associated with the nematodes in practically all instances of infection. Many small feeder roots of apple, avocado, citrus, grape, and walnut were completely girdled. Some plants such as bean, crotalaria, and pea were preferred hosts in that large numbers of nematodes were recovered from the extensive necrotic areas of the root systems. The nematodes were barely able to maintain themselves on other plants such as alfalfa and cabbage.

Trials designed to discover cover crops non-susceptible to P. penetrans involved 33 different kinds of plants. All of the plants used in these trials were found to be hosts for this nematode although the number recovered from the root tissues was extremely variable. The major differences in the experimental host ranges of the two species presented in these data are that P. penetrans is attracted to the Gramineae while P. vulnus apparently avoids them.

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY. OREGON STATE COLLEGE AGRICULTURAL EXPERIMENT STATION, CORVALLIS, OREGON

# A SEED NEMATODE OBSERVED IN ORCHARD GRASS IN OREGON[1]

John R. Hardison and H. J. Jensen[2]

Three malformed panicles bearing nematode galls in place of seeds were found May 26, 1947 in orchard grass, Dactylis glomerata L., on the Oregon Agricultural Experiment Station farm at Granger, Oregon. The affected orchard grass inflorescences were distorted considerably (Fig. 1). The disease is caused by a nematode in the genus Anguina. Anguina agrostis (Steinbuch) Filipjev causes economically serious seed gall diseases in Astoria bentgrass, Agrostis tenuis Sibth., Seaside bentgrass, A. palustris Huds., and chewings fescue, Festuca rubra var. commutata Gaud., in Oregon.

FIGURE 1. (left) Panicles of orchard grass infested with seed nematode. Healthy on left. (About 3/4 X.)

FIGURE 2. Seed nematode galls in orchard grass spikelets. Healthy on left. (About 3 3/4 X.)

[1]Cooperative investigations between the Division of Forage Crops and Diseases, United States Department of Agriculture and the Department of Botany and Plant Pathology, Oregon Agricultural Experiment Station.

[2]Pathologist, Division of Forage Crops and Diseases and Oregon Agricultural Experiment Station and Assistant Nematologist, Oregon Agricultural Experiment Station, respectively.

Fewer galls were found in the orchard grass heads than might be expected from the effects on the panicles. The galls were short and thick (Fig. 2); whereas those on bentgrass and chewings fescue incited by Anguina agrostis are long and thin.

The specimens were found in apparently volunteer plants of Akaroa orchard grass, F. C. 22400. The plants were growing adjacent to a rod row of Akaroa in an observational grass nursery. Plants in this and other adjacent rows had been harvested in a manner that largely excludes seed shattering, which probably explains the lack of increase of the nematode.

No similar symptoms in orchard grass have been seen in grass nurseries or fields in Washington, Michigan, Kentucky, or in Oregon prior to or since the discovery of these specimens. A special search during the period 1947 to 1953 to find additional specimens in Oregon was made without success.

The limited material is being propagated for further study.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, OREGON AGRICULTURAL EXPERIMENT STATION, CORVALLIS, OREGON

# ISOLATION OF ALFALFA MOSAIC VIRUS STRAINS FROM FIELD-GROWN BEANS

H. R. Thomas

Hybrid snap beans (Phaseolus vulgaris L.) grown in experimental plots near Hermiston, Oregon, and Prosser, Washington, for the elimination of lines susceptible to curly top virus are often severely mottled and stunted by viruses other than the curly top. A reddish-brown blemish of the pods (Fig. 1) also has been frequently observed on beans in these two locations as well as near Twin Falls, Idaho. Most of the hybrid beans observed were resistant to common bean mosaic virus and until 1949 the leaf mottling symptom was thought to be caused by viruses in the yellow bean mosaic virus group. Then, yellow dot virus, a strain of alfalfa mosaic virus, was isolated from mottled leaves of bean plants growing near Prosser (4). A year later the same virus was isolated from alfalfa growing near Twin Falls. More recently other strains of alfalfa mosaic virus causing systemic mottling in beans have been described (2, 3, 6). A strain of cucumber mosaic virus that caused a systemic mottle in beans was isolated from an alfalfa plant growing near Jerome, Idaho, where the virus occurred in combination with alfalfa yellow mosaic virus (1). Because of the similarity of symptoms produced in beans by the yellow bean mosaic virus, certain strains of the alfalfa mosaic virus, and certain strains of cucumber mosaic virus, it is difficult in the field to know which of the viruses is present. In some cases, two viruses have been isolated from the same plant (4, 5).

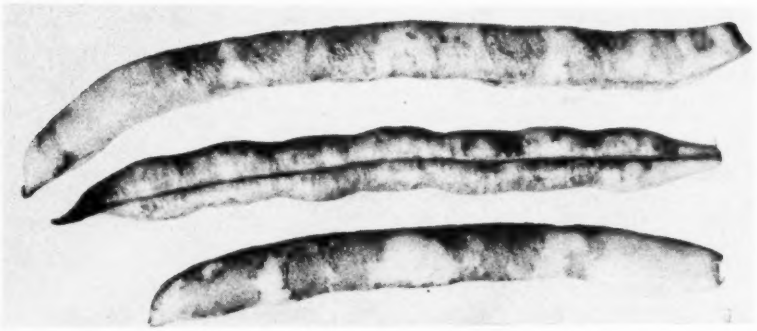

FIGURE 1. Reddish-brown blemish of Blue Lake pods from field-grown beans. A strain of alfalfa mosaic virus was isolated from bean pods with similar symptoms.

To determine which, if any, of these three viruses was present in infected beans in certain areas in the West, 11 collections were made of bean pods or leaves, most of which had symptoms similar to those caused by yellow bean mosaic virus, were made during July and August 1952. Four were made near Prosser, Washington, two near Worland, Wyoming, and five near Twin Falls, Idaho. In one sample collected near Prosser the pods had a reddish-brown blemish, a symptom not associated with yellow bean mosaic. One sample from Twin Falls came from Kentucky Wonder bean having no leaf mottle, but extensive veinal and stem necrosis, a symptom associated with infection by certain strains of yellow bean mosaic virus.

The identification of these virus collections showed that four belonged to the alfalfa mosaic virus group and seven to the yellow bean mosaic virus group. Three of the former came from the Twin Falls area and the other from Prosser.

The four alfalfa mosaic virus isolates were not compared in detail among themselves or with other previously described strains of this virus. All caused systemic infection of beans. On Michelite bean they produced a few large local lesions and veinal necrosis on the inoculated leaves; stem necrosis, mild systemic mottle, and some yellow spotting followed. On rubbed leaves of Bountiful bean a few necrotic lesions and small necrotic bands bordering the veins and veinlets developed; mild mottle and yellow spotting of the trifoliate leaves followed. The plants were discarded before pod formation; so pod symptoms were not determined. A reddish-brown blemish developed on pods of Topcrop plants inoculated with the alfalfa mosaic virus isolate from Prosser; this blemish was similar to that in the field-grown pods from which the isolate

was obtained. Similar pod symptoms were also produced on Topcrop bean by one of the alfalfa mosaic virus isolates collected near Twin Falls from a bean plant with light and dark green leaf and pod mottling but no reddish-brown pod discoloration.

On tepary bean (Phaseolus acutifolius var. latifolius Freeman) all four isolates in the alfalfa mosaic virus group produced necrotic local lesions. All the yellow bean mosaic virus isolates produced veinal necrosis on the inoculated leaves followed by systemic mottle or systemic necrosis. Tepary bean has proved to be a suitable host for property studies of the strains of alfalfa mosaic virus systemic on beans because of the numerous well-defined local lesions produced. It also has been useful in separating yellow bean mosaic virus from alfalfa mosaic virus strains systemic on beans as none of the latter group studied were systemic in tepary bean whereas the yellow bean mosaic virus strains were. None of the yellow bean mosaic virus strains produced local lesions on tepary bean.

On Turkish tobacco the alfalfa mosaic virus isolates produced indistinct chlorotic local lesions followed by pronounced systemic mottle, often accomoanied by white markings of the oak-leaf pattern type. As the plants became older these symptoms disappeared. On Wisconsin Perfection pea, stem streaking and stunting occurred. On Blackeye cowpea, Datura stramonium L., and zinnia, systemic mottle developed. Cucumber was difficult to infect and symptoms, usually consisting of faint vein-clearing and indistinct yellow markings, were not pronounced. Spinach was not infected.

Isolation of strains of alfalfa mosaic virus causing a systemic mottle in beans from snap beans growing in Idaho and Washington shows that they are responsible for some of the leaf mottling observed in the field. Preliminary data suggest that the reddish-brown blemish of bean pods observed in this area may be caused by strains of alfalfa mosaic virus.

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# ASSOCIATION OF A STRAIN OF THE TOBACCO RINGSPOT VIRUS WITH PIMPLES DISEASE OF WATERMELONS IN TEXAS

David W. Rosberg

The incidence of a condition in watermelon fruits variously known as pimples, bumps, measles, sandbumps, and warts has increased annually in Texas during the past several years. The symptoms of pimples are very similar macroscopically to those of early fruit lesions of anthracnose, caused by Colletotrichum lagenarium (Pass.) Ell. & Halst., and are therefore commonly confused. The two diseases are readily distinguished, however, by microscopic examination, or by holding the fruits for observation. The similarity of the conditions is a major problem during loading for shipment, because the grader must make a distinction on the spot, without benefit of microscopy or a holding period. Generally both diseases are classed as anthracnose and culled accordingly. During the dry summers of 1951 and 1952 when anthracnose was virtually non-existent in Texas production areas, this problem caused great concern among growers. In certain instances during these two years losses, often amounting to 50 percent of the crop, resulted from grading of melons culled for "anthracnose" but which actually was pimples.

In the case of pimples disease, mycelial invasion of the rind tissue is absent and the slight elevations on the surface remain unchanged except for the development of tan to brownish areas in the rind tissue immediately beneath the pimpled surface. In watermelon anthracnose, mycelial invasion is microscopically apparent in very young lesions, which gradually become concave, enlarge, and involve the inner tissues, resulting in a general and rapid breakdown of infected fruits.

In September 1952 the pimpled rind tissue from three Black Diamond (also known as Florida Giant) watermelons, one selected from a second-growth vine in the field and two purchased from a roadside vendor, was frozen and macerated and the sap was expressed. The leaves of young Burley tobacco plants, previously lightly dusted with 340-mesh carborundum, were inoculated by rubbing gently with a cheesecloth pad soaked in expressed sap. In all inoculations control tobacco plants were similarly treated, distilled water being substituted for expressed sap. Within ten days, typical chlorotic and necrotic ringspots and later an oak-leaf pattern developed in the leaves of the nine tobacco plants inoculated with expressed sap (Fig. 1). Symptoms did not develop in control plants. Expressed sap preparations from the leaves of these tobacco plants were inoculated to an additional 18 Burley tobacco plants, all of which developed ringspot symptoms within 12 days and a jagged oak-leaf pattern a week or so later. Expressed sap preparations from several of these plants was used in greenhouse inoculations to six plants each of watermelon, Black Diamond and Dixie Queen; squash, Early Prolific; cucumber, Maine No. 2; bean, Black Valentine, Tendergreen, and Plentiful; cowpea, Extra Early Blackeye Pea and Purple Hull No. 49; pea, Alaska; and petunia, Petunia hybrida Velm. Systemic symptoms, expressed as a mild to severe leaf mottle, developed in the squash and cucumber plants (Fig. 2). Mottling developed in the terminal leaves of one of the watermelon plants, becoming completely masked after 18 days. The systemic mottling in the squash and cucumber plants persisted in the inoculated leaves and developed in all leaves subsequently formed. Local lesions developing in watermelon leaves inoculated with the virus were indistinguishable macroscopically from the necrotic leaf lesions produced by the anthracnose fungus (Fig. 3). In the greenhouse during the winter months, four watermelon fruits from four of 24 plants developed typical pimple symptoms four to seven weeks after leaf inoculation with expressed sap from Burley tobacco plants showing ringspot symptoms (Fig. 4). The fruits on three of the plants were set before and the fourth after inoculation of the leaves. On two inoculated plants which produced small but mature fruits local foliar necroses appeared, but the fruits remained symptomless. In the remaining 18 inoculated plants typical leaf necroses developed but the fruits aborted or rotted at the blossom end before any symptoms were expressed.

After inoculation all the varieties of bean, cowpea, and pea developed reddish-colored local leaf lesions. Of the leguminous plants tested, only Extra Early Blackeye Pea became severely infected systemically. The terminals of all plants died 8 to 15 days after inoculation (Fig. 5). Mild systemic infection in bean produced stunting and mottling in later-formed leaves (Fig. 6).

To determine whether or not the yellowed leaves of an otherwise symptomless Burley tobacco plant that had been inoculated in September 1952 with expressed sap from the rind of a pimpled watermelon fruit still contained an infectious concentration of the ringspot virus, yellowed leaves were harvested in April 1953, frozen and macerated. The sap was expressed from them and inoculated into the leaves of four young Extra Early Blackeye Pea plants. On the eighth day

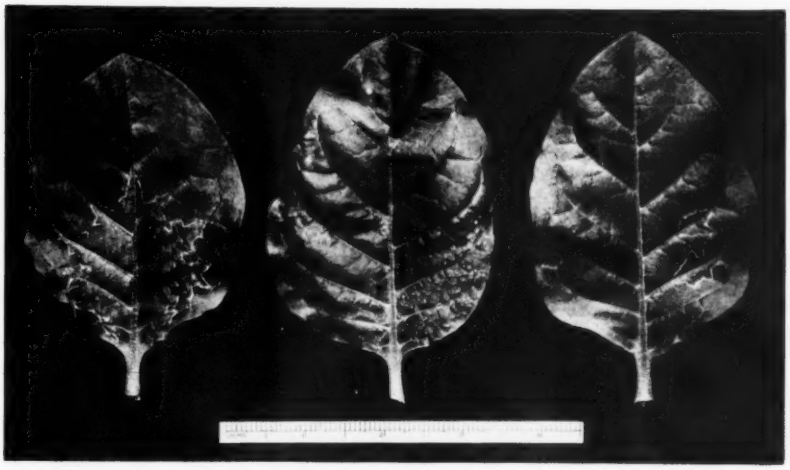

FIGURE 1. Systemically infected Burley tobacco leaves showing typical ringspot symptoms.

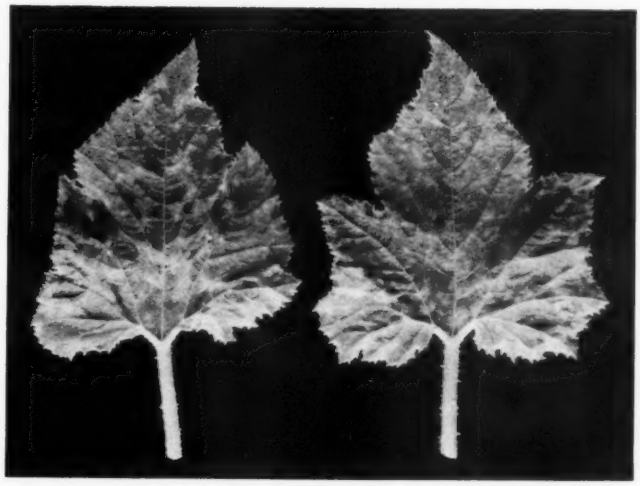

FIGURE 2. Systemic leaf mottle symptoms in Early Prolific squash.

FIGURE 3. Local necrotic lesions in inoculated leaf of Black Diamond watermelon.

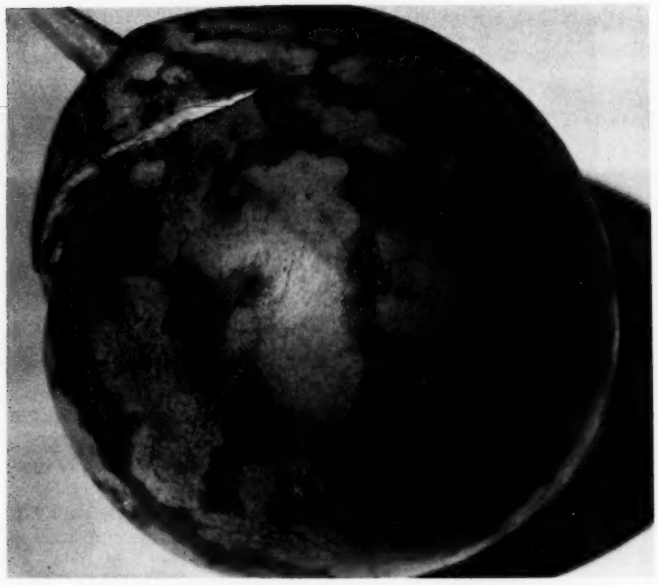

FIGURE 4. Dixie Queen watermelon which developed pimples after leaf inoculation with expressed sap from a ringspotted tobacco plant.

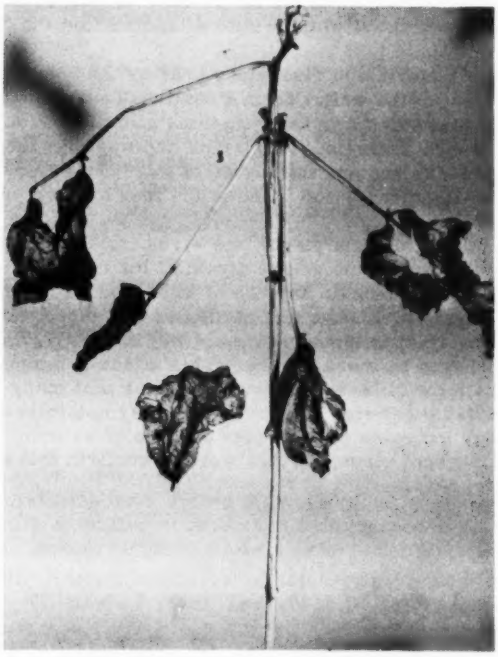

FIGURE 5. Terminal necrosis in inoculated Extra Early Blackeye pea plant.

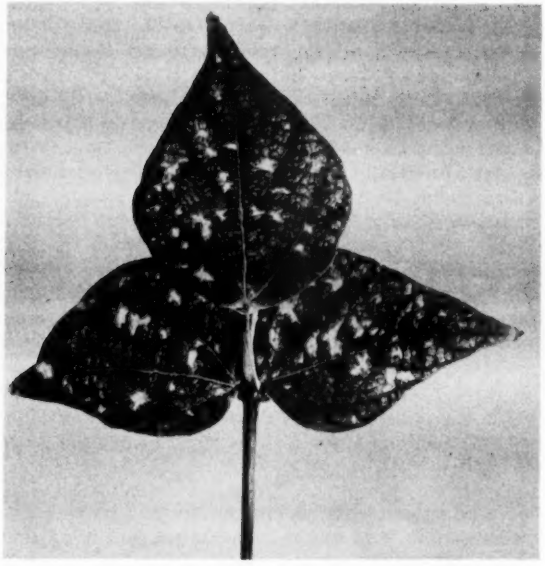

FIGURE 6. Systemic mottle in inoculated leaf of Plentiful bean plant.

after inoculation, the four plants developed typical reddish local lesions. Infection became systemic in two of the plants, the terminals of which withered and died on the fifteenth day after inoculation.

On May 15, 1953, two pieces of watermelon rind considered by the sender to be infected with the anthracnose fungus were sent to the writer from Beeville, Texas for examination and diagnosis. The rind pieces exhibited typical pimples symptoms and microscopic examination did not reveal the presence of hyphae or bacteria. Expressed sap was prepared from the two pieces of rind tissue as previously described and the leaves of four young Burley tobacco plants were inoculated. On the ninth day after inoculation three of the four tobacco plants exhibited chlorotic ringspot symptoms.

Except for the apparent immunity of petunia plants, the virus isolated from pimpled watermelon fruits appears to be closely related to the yellow strain of the tobacco ringspot virus which Pound (1) found to be the cause of a mosaic disease of watermelons and muskmelon in Wisconsin. Pound found in inoculations to tobacco and cucumber that there was a marked tendency toward recovery (masked symptoms) at temperatures of 24° to 28° C., while at 16° C. symptoms were persistent and tended to be more severe. This effect of temperature on the expression of symptoms may explain the observation made in Texas that many watermelon plants that produce pimpled fruits are otherwise macroscopically symptomless.

Although this preliminary study indicates that pimples disease of watermelon fruits is caused by a strain of the tobacco ringspot virus, further work to confirm this conclusion and devise methods of control is in progress.

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# EVALUATION OF FUNGICIDES AS PROTECTANTS OF COTTON SEEDLINGS FROM INFECTION BY RHIZOCTONIA SOLANI[1]

C. H. Arndt

The most widely used technique in the past for the evaluation of chemicals as seed and seedling protectants has been that of culturing treated seeds in soil naturally infested by the pathogens that generally infect the seedlings (2, 3). Although this technique has facilitated the development of effective fungicides for seed treatment, its value has been limited by the inherent difficulties of obtaining soil of a uniform disease-producing potential. It also is not readily adaptable to the evaluation of fungicides as possible seed and seedling protectants when they are applied directly into the seed furrow. The technique described in this paper seems to lack some of the inherent defects of previously described techniques; and it has been found satisfactory for the evaluation of chemicals as seed and seedling protectants when Rhizoctonia solani is the infecting fungus.

## Methods

The technique described is a modification of that used as a standard method for evaluating fungicides for the treatment of fuzzy cotton seed infested by Colletotrichum gossypii (1). Twenty-five hundred grams of air-dry river sand of 36 percent water-holding capacity were placed in 11 x 20 cm. circular aluminum dishes (Fig. 1), which were then steamed at 115°C. for one hour. After cooling, a sufficient amount of a nutrient solution (1) was added to bring the moisture content of the sand to 80 percent of its field capacity. The moistened sand was then thoroughly stirred with an ice pick to obtain adequate aeration, and the surface leveled. Thirty-two holes 12 mm. in diameter and 30 mm. deep were next formed in the upper portion of the sand by means of a cylindrical punch and a template in which 32 regularly spaced holes 14 mm. in diameter had been drilled (Fig. 1). These holes were arranged in three rings of 4 (center), 10 (middle), and 18 (outer) holes in each.

A 5 mm. layer of dry sand with which the requisite amount of the fungicide had been mixed was poured into each of the 28 holes in the outer two rings. One acid-delinted cotton seed was next dropped into each of these holes, after which the hole was filled with the same mixture of sand and fungicide. Approximately, 180 gm. of dry sand were required to fill the 32 holes. This increase in weight was taken into consideration when adding the amount of water required to maintain the cultures at the desired moisture content.

The fungicide-sand mixtures were prepared by mixing a given amount of the fungicide and sand in a ball mill. The original mixture usually contained 1 percent of the fungicide. Further dilutions were prepared from the 1 percent mixtures. All concentrations of the fungicides are reported on an active chemical basis.

Isolates of Rhizoctonia solani that had been obtained from naturally infected cotton seedlings were grown on oats-raisin agar slants. Five- to seven-day cultures of these were macerated in a Waring blendor for 20 seconds, after which several drops of the macerate were poured over steamed barley seeds in a Petri dish. One of these seeds was next dropped into each of the four holes in the center of the sand cultures. These holes were then filled with steamed, dry sand to which a fungicide had not been added. The cultures were maintained at 23° to 25°C. in chambers which were illuminated with fluorescent lamps after seedling emergence. Two types of controls were used: In one, the barley seeds were not inoculated, while in the other they were inoculated similarly to the cultures to which the fungicide had been added. In the latter cultures, the first visible injury by the fungus appeared in the circle of 10 seedlings, about 2 cm. from the inoculated barley seeds, after 5 days; in the outer row of 18 seedlings, approximately 4 cm., after 7 days.

## Results and Discussion

The results reported in this paper, Table 1, were obtained in the last of a series of experiments in which (a) the highest concentrations of the chemicals that were non-toxic to cotton seedlings and (b) the effect of these concentrations on the infection of the seedlings by Rhizoctonia solani were ascertained. It was not considered essential to include the data obtained in the earlier tests, since the results obtained were comparable to those for the experiment reported

[1]Technical contribution No. 214 of the South Carolina Agricultural Experimental Station.

Table 1. Number of surviving cotton seedlings per 84 seeds planted in cultures inoculated with Rhizoctonia solani, and treated with the several fungicides at the dilutions indicated.

| Treatment[a] | Healthy seedlings after number of days indicated | | | |
|---|---|---|---|---|
| | 5 | 7 | 9 | 12 |
| 1. Check, no fungus | 78 | 78 | 78 | 78 |
| 2. Check + fungus | 76 | 27 | 0 | -- |
| 3. Chloranil 1:20,000 | 66 | 0 | 0 | -- |
| 4. Thiram 1:20,000 | 68 | 23 | 0 | -- |
| 5. Zineb 1:20,000 | 78 | 29 | 0 | -- |
| 6. Captan 1:20,000 | 76 | 27 | 0 | -- |
| 7. Sodium salts of dimethyl dithiocarbamic acid and 2-mercaptobenzothiazole 1:20,000 | 73 | 27 | 0 | -- |
| 8. 2,4 dinitrofluorobenzene 1:160,000 | 73 | 25 | 0 | -- |
| 9. Na-tetrachlorophenate 1:80,000 | 78 | 72 | 69 | 50 |
| 10. Trichlorophenyl acetate 1:20,000 | 77 | 75 | 69 | 61 |
| 11. Pentachloronitrobenzene 1:20,000 | 77 | 76 | 73 | 68 |

[a]The trade names of the chemicals used and the supplying companies were as follows: 3, Spergon, U. S. Rubber Co.; 4, Arasan, duPont de Nemours & Co.; 5, Dithane Z78, Rohm and Haas Co.; 6, Orthocide 406, California Spray Chemical Corp.; 7, Vancide 51, R. T. Vanderbilt Co.; 8, NP-1083, Pennsylvania Salt Mfg. Co.; 9, Dowicide F, Dow Chemical Co.; 10, Seedox, Sindar Corp.; 11, 275-D, Mathieson Chemical Corp.

here, and the results should be considered merely indicative of those that may be obtained by the use of this technique. Also, the main objective of this paper is to describe the technique. As indicated by the number of surviving seedlings, Table 1, chloranil appeared to enhance seedling infection by R. solani; while the seedling survival after 7 days was about the same in the check cultures inoculated with the fungus and those treated with thiram, zineb, captan, sodium salts of dimethyl dithiocarbamic acid and 2-mercaptobenzothiazole, and 2,4 dinitrofluorobenzene. The differences among the cultures treated with the more effective fungicides, sodium tetrachlorophenate, trichlorophenyl acetate, and pentachloronitrobenzene, were negligible after 7 and 9 days. They were, however, greater after 12 days.

These results would seem to indicate that tetrachlorophenol and trichlorophenol derivatives and pentachloronitrobenzene may be of special value for use as seed and seedling protectants when R. solani is the pathogen to be controlled. These results, however, need to be verified by tests carried out under other conditions and in field plantings.

In this experiment a varying number of the taproots of the surviving seedlings which had emerged beyond the chemically treated zone were rotted by R. solani. The percentage of roots of surviving seedlings with the cortex thus rooted for the treatments sodium tetrachlorophenate, trichlorophenyl acetate, and pentachloronitrobenzene were 40, 25, and 24. The interesting feature of this cortical rot was the sharp boundary between the rotted and apparently healthy portion at the margin of the treated zone of the sand (Fig. 2). The failure of the fungus to infect the inner portion of the cortex in the chemically treated zone would seem to indicate that these chemicals retarded the growth of the fungus in cells not directly in contact with the chemical. A small percentage of these same seedlings showed Rhizoctonia-induced lesions at and above the soil surface (Fig. 2).

An interesting pecularity of these results was the failure of such known effective seed protectants as thiram, captan, and chloranil at the rate used to reduce infection by R. solani. Further studies will be necessary to ascertain whether they prevent or delay seedling infection by R. solani under conditions other than those of these tests or whether the favorable results that have been obtained with them in field plantings have been associated with protection from infection by other pathogens.

A significant characteristic of the technique used in these experiments is the numerous ways in which it can be modified to facilitate the evaluation of seed and seedling protectants

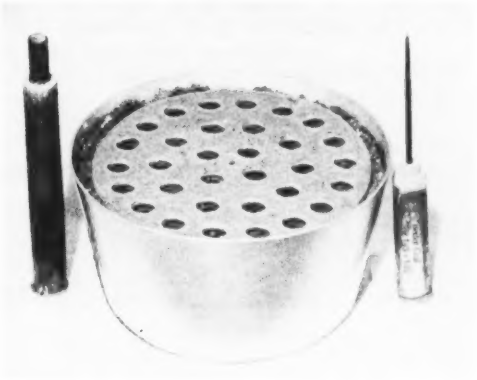

FIGURE 1. Container used for sand cultures, ice pick used for stirring sand after addition of nutrient solution, and template and punch used for making appropriate holes in sand.

FIGURE 2. Protective effect of pentachloronitrobenzene on invasion of cortex of taproot by R. solani. Original position of seed slightly above uppermost secondary roots, with zone of treated sand extending from slightly below seed to surface of sand, which is indicated by lower margin of lesion on hypocotyl (indicated by sharply reduced diameter) of seedling on the right. Seedling on left not infected. Three seedlings on right with cortex of taproots below treated zone more or less completely rotted. Only remnant of the lower portion of the taproots is the thread-like stele.

under the various environmental conditions that may be encountered in field plantings.

## Summary

A sand-culture technique for evaluating chemicals as seed and seedling protectants is described. It differs from those previously used in that the chemical is applied only to sand immediately around the seed and the cultures can be inoculated with specific pathogens. Sodium tetrachlorophenate, trichlorophenyl acetate, and pentachloronitrobenzene are shown to afford cotton seedlings significant protection from infection by Rhizoctonia solani during a 12-day culture period at 24°C. A number of other fungicides that have been used as seed protectants did not retard infection by this fungus.

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## SORGHUM SEED TREATMENT IN SOUTH DAKOTA

R. H. Converse[1] and C. M. Nagel[2]

Fungicidal seed treatments for sorghum have been evaluated in South Dakota since 1942 in an attempt to increase the stands of early planted sorghum. The results of tests performed through 1945 were reported by Buchholtz[3, 4], while those from 1948 through 1952 are summarized herein. The grain sorghum variety Norghum was used for all tests in the latter period.

Table 1. A list of sorghum seed treatment fungicides that did not produce yields significantly better than controls, 1948-1952, at Brookings and Highmore, South Dakota[a].

| Fungicide | Dosage oz/bu. | Number of plantings treatment was used |
|---|---|---|
| Aagrano 350 | 0.5 | 4 |
| Arasan | 2.0-3.0 | 9 |
| Arasan-Phygon | 1.0-0.5 | 2 |
| Carbide & Carbon 224 slurry | 2.0 | 2 |
| Carbide & Carbon 224 as row treatment | 2.0+4.4 lb./acre | 1 |
| Carbide & Carbon 5400 | 2.0 | 5 |
| Cargill | 2.0 | 2 |
| Ceresan | 0.5 | 3 |
| Ceresan M. dust | 0.5-1.5 | 11 |
| Ceresan M. slurry | 0.5 | 2 |
| 5% Copper Naphthenate | 1.5 | 6 |
| 20% Copper Naphthenate | 1.5 | 3 |
| Dow 9B | 1.5 | 6 |
| M.T.H. | 1.0 | 6 |
| Fermate | 2.0 | 3 |
| Mercuran A.S. | 0.5 | 6 |
| 5% Mercury Naphthenate | 1.5 | 6 |
| 20% Mercury Naphthenate | 1.5 | 6 |
| NP-4B | 1.0 | 2 |
| New Improved Ceresan | 1.5 | 3 |
| Panogen | 0.75-1 fl. oz. | 5 |
| Phygon | 1.0 | 14 |
| Phygon XL slurry | 1.0 | 2 |
| Semesan Jr. | 2.0 | 6 |
| Spergon SL slurry | 1.5 | 2 |
| Tennessee 34 | 3.0 | 3 |
| Tribasic Copper Sulfate | 2.0 | 3 |
| Vancide 51 | 4.0 | 2 |
| Yellow Cuprocide | 1.5 | 3 |
| Zerlate | 2.0 | 3 |
| 5% Zinc Naphthenate | 1.5 | 6 |
| 20% Zinc Naphthenate | 1.5 | 6 |
| Zinc Oxide | 0.5 | 3 |

[a]Grouping wettable and non-wettable formulations applied as dusts.

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Table 2. Sorghum seed treatment fungicides that produced yields significantly better than controls one or more times during the period 1948-1952, when grown at Brookings and Highmore, South Dakota.

| Fungicides | Dosage oz/bu. | Yield in bu./acre from plantings on given dates in indicated years | | | | | | | | | | | | | | | | Number of plantings | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | At Brookings | | | | | | | | | | | At Highmore | | | | | Given fungicide used | Yield significantly increased over control |
| | | 1948 | | | 1949 | | | 1950 | | 1951 | | | 1951 | | | 1952 | | | |
| | | May 7 | May 22 | June 5 | May 8 | May 20 | June 6 | May 27 | June 5 | May 24 | June 5 | June 15 | May 23 | June 4 | June 12 | May 15 | May 26 | | |
| Arasan SF slurry | 1.5 | ---[a] | --- | --- | --- | --- | --- | 50.2[b] | 21.6 | 30.3 | 20.9 | 4.7 | 6.7 | 9.7 | 4.9 | 31.0 | 31.9 | 10 | 2 |
| Arasan[c] + row dust[d] | 1.5 | --- | --- | --- | --- | --- | --- | --- | --- | 17.5 | 11.4 | 0.7 | 10.1 | 7.4 | 4.4 | 37.0 | 35.7 | 8 | 1 |
| Arasan-Spergon[e] | 0.75:1.5 | --- | --- | --- | --- | --- | --- | 57.2 | 23.2 | 29.0 | 22.0 | 4.0 | 4.7 | 8.8 | 5.0 | --- | --- | 8 | 2 |
| COCS Special C-1 | 2.0 | --- | --- | --- | --- | --- | --- | --- | --- | 29.6 | 23.6 | 4.7 | --- | --- | --- | --- | --- | 3 | 1 |
| Carbide & Carbon 224 | 2.0 | --- | --- | --- | --- | --- | --- | 55.6 | 19.1 | 33.0 | 25.6 | 4.7 | 9.4 | 12.0 | 8.0 | 38.4 | 41.1 | 10 | 7 |
| Carbide & Carbon 640 | 2.0 | 6 | --- | --- | --- | --- | --- | 54.0 | 23.7 | 26.3 | 25.6 | 4.7 | 10.8 | 8.8 | 6.6 | 34.3 | 37.0 | 10 | 4 |
| Carbide & Carbon 640 + row dust[d] | 2.0 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 33.9 | 1 | 1 |
| Copper Carbonate | 5.0[f] | 53.1 | 52.2 | 31.1 | 46.3 | 58.6 | 36.2 | --- | --- | 30.3 | 19.5 | 4.7 | 9.4 | 8.2 | 7.3 | --- | --- | 12 | 2 |
| Orthocide 406 | 2.0 | --- | --- | --- | --- | --- | --- | 50.4 | 12.4 | 28.3 | 18.2 | 4.0 | --- | --- | --- | --- | --- | 5 | 1 |
| Panogen S | 1 fl. oz. | --- | --- | --- | --- | --- | --- | 52.8 | 19.1 | 23.6 | 19.5 | 3.4 | 8.1 | 10.6 | 8.5 | 22.9 | 25.6 | 10 | 3 |
| Spergon[e] | 2.0[g] | 69.0 | 56.2 | 28.8 | 51.0 | 64.4 | 28.4 | 50.1 | 21.0 | 29.0 | 19.5 | 3.4 | 7.4 | 9.8 | 6.1 | 29.0 | 29.6 | 16 | 3 |
| Tennessee 26 | 4.0 | --- | --- | --- | --- | --- | --- | --- | --- | 29.0 | 23.6 | 4.0 | --- | --- | --- | --- | --- | 3 | 1 |
| Control (No fungicide) | --- | 64.0 | 49.4 | 31.0 | 45.4 | 51.2 | 35.5 | 42.3 | 19.3 | 20.9 | 18.9 | 2.7 | 7.4 | 6.7 | 4.9 | 29.6 | 22.9 | | |
| L. S. D. (19:1) | --- | 12.9 | 15.5 | 11.0 | 15.2 | 9.5 | 10.2 | 7.0 | 8.1 | 8.1 | 6.0 | 2.2 | 3.3 | 3.2 | 2.1 | 8.5 | 10.2 | | |

[a] Dash indicates the fungicide was not used in that planting.
[b] Underline indicates a significant increase in yield as compared to the control.
[c] Arasan SF slurry and row dust used in 1952.
[d] The fungicide was added to the row at the rate of 4.4 lb./acre.
[e] Grouping wettable and non-wettable formulations applied as dusts.
[f] 3 oz/bu. 1948, 1949; 5 oz/bu. 1951.
[g] 3 oz/bu. 1948, 1949; 1.5 oz/bu. 1950; 2 oz/bu. 1951, 1952.

Thirty-three fungicides were tested over the five-year period, but not all of them were tested in any one year. New fungicides were added to the list and ineffective ones were removed with each succeeding year of the tests. All of these fungicides were tested at Brookings, South Dakota, during the four-year period 1948-1951, and selected fungicides were tested at Highmore, South Dakota in the main sorghum production area of the State in 1951 and 1952.

The fungicides were applied at the manufacturer's recommended dosages where specified. Most of the fungicides were applied as dusts. A few were applied as slurries and a few as soil treatments in the row.

The seeds were planted in five replicates (four in 1948) in randomized blocks. One hundred seeds were planted in two row plots 33 feet long, with 3 1/2 feet between rows. Early (mid-May), medium (late May), and late (early June) plantings were made each year except in 1950 and 1952, when the early planting and late planting respectively were omitted. Stand counts were made each year except 1950, and grain yields were taken each year.

Significant correlations between stand and yield were found in 13 of the 14 plantings from which data were available. The average correlation coefficient between stand and yield for all of the first planting dates was $+0.9090 \pm 0.13$, which is significant at the 1% level. It is apparent that the stand counts of early plantings were, in every case, good estimates of the yields obtained and can be used with confidence in screening additional fungicides. The conclusion of Buchholtz[4], that yield is primarily a function of stand when the environment is unfavorable to the germination of sorghum, is thus supported.

The seed treatment materials that gave significant increases in yields over comparable controls at least once during the five-year period are listed in Table 2, together with the actual yields obtained. Fungicides that gave no increase in yield are listed in Table 1. In his experiments, Buchholtz[3, 4] found that Spergon, Arasan, and copper carbonate were effective seed treatments in the field in South Dakota. The data presented here indicate that Carbide and Carbon compounds Nos. 224 and 640, Panogen S, Arasan-Spergon mixture, and Arasan SF slurry were the best seed treatment materials to use on sorghum. Carbide and Carbon compound No. 224 has given the most consistent yield increases of any material tested to date. However, it increased the stand in the field to no more than 50 percent of that obtained in laboratory germination of the seed.

The slurry application of Arasan was more effective than the dust application. The reverse was true for Carbide and Carbon compound No. 224.

In 1951 and 1952 Arasan[5] and Carbide and Carbon Compounds Nos. 224 and 640 were added to the soil in the row at the rate of 4.4 pounds per acre at planting time. Seeds treated with the above materials were planted in both treated and untreated rows. Yields in soil treated with Arasan or Carbide and Carbon compound No. 640 were similar to yields of comparably treated seed in untreated soil. The presence of Carbide and Carbon compound No. 224 in the soil markedly decreased the yield below that from untreated soil.

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[5]Arasan was used in 1951; Arasan SF was applied both as a slurry to the seeds, and as a dust in the row 1952.

# USE OF STREPTOMYCIN DUST TO CONTROL FIRE BLIGHT

Peter A. Ark[1]

The spring of 1953 was an epiphytotic year in California for fire blight. The blossom phase of the blight is the most important phase in the areas considered here. If the disease is not controlled at this stage, twigs and branches can become involved. Increase in atmospheric humidity leads to dilution, among other constituents, of the sugar content of the pear blossom nectar, thus favoring development of Erwinia amylovora. On the other hand, a drop in relative humidity tends to increase concentration of sugar in the nectary making conditions unfavorable for the fire blight bacteria (5, 6, 7). This concept of the blight epiphytotics aided in the development of preventive measures against blossom infection at the time when the disease is likely to be greatly accelerated in the orchard by wet weather.

For a number of years, both spraying and dusting of pears with copper-containing materials during blossom time has been employed by pear growers with a great deal of success. Successful control depends on proper timing, and omission of either dusting or spraying at some one critical period can result in considerable blight. Depending on the weather and duration of blooming, usually five to twelve applications are made during a period of six weeks or more. However, in some situations use of copper to control fire blight results in a considerable russetting of fruit. Thus pear growers are confronted with the problem of finding a suitable material that will not russet the fruit while still controlling the blight.

In a search for new chemicals to control bacterial diseases of plants various antibiotics were tested in the laboratory against Erwinia amylovora. The high degree of plant tolerance for streptomycin, as reported by the writer and others (1, 2, 3, 4), encouraged the use of this antibiotic in fire blight work. Preliminary tests showed that the blossoms of Pyracantha yunnanensis, apple, and pear were not injured by concentrations ranging from 30 to 400 p.p.m. when either sprayed or dusted repeatedly (four times within ten days). These concentrations produced no visible injury in tender detached shoots left in the streptomycin solutions at room temperature for two weeks. Such a remarkable degree of freedom from injury led to field trials. It was then decided to test the efficacy of crude streptomycin combined with bentonite dust.

In previous work with streptomycin (2, 3) better results were obtained with the antibiotic adsorbed to IRC-50 resin ground to the size of 8 microns. Later tests showed that impregnation of bentonite dust with streptomycin gave equally good results. Therefore it was planned to use bentonite dust impregnated with crude streptomycin, with the final concentration of streptomycin base in the finished product equal to 240 p.p.m.[2] Three hundred and twenty Bartlett pear trees were dusted with this streptomycin dust, by means of a powerful duster having an air displacement rating of about 80,000 cu. ft. per minute[3]. The dust was applied at the rate of 30 pounds or more per acre. Two adjoining plots of 290 and 260 Bartlett pears each were used as untreated checks. In addition, a plot consisting of 300 trees was treated with monohydrate copper sulfate dust, 20%, in lime. All plots were also sprayed twice for scab (Venturia pyrina) in March and twice for codling moth in April. Copper (to serve as a bactericide) was included in these sprays only in the copper plot previously mentioned.

Evaluation of blight incidence is based on the number of cuts made to remove blighted parts from the trees. The total number of blight cuts made in a given plot divided by the number of trees in the plot is used to indicate severity of the blight.

Owing to the long blossoming period, the critical period for the fire hazard in 1953 extended from March 20 to May 1. Full bloom stage was on March 27, but many straggling secondary blossoms opened afterward. During this period there were ten days of rain. Daily rains fell from March 26 (1.20 inch) to April 30. The copper plot received eight applications while the streptomycin plot had only four and, owing to conditions beyond control, the timing of the latter was somewhat out of line with those in the copper plot on the most dangerous dates (Table 1). In spite of this handicap, up to May 1 the streptomycin plot was showing outstanding control of the disease.

Streptomycin gave good performance not only in blight control but also in causing no fruit

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[2]The writer is grateful to the Merck and Co., Inc., of Rahway, New Jersey, for supplying generous amounts of crude streptomycin for this work.

[3]Gratitude is expressed to Di Giorgio Fruit Corporation at Marysville, California, for its generous cooperation and very valuable aid in carrying out the experimental work reported here.

Table 1. Results of copper and crude streptomycin treatments for control of pear fire blight applied as dusts March 23 to April 30, 1953. Scab sprays: March 5 and 16. Codling moth sprays: April 4 and 24. Experiments in California.

| Treatment | Total number trees | Dusting dates | Blight cuts to May 1 | | |
|---|---|---|---|---|---|
| | | | Total | Per tree | Percentage in relation to check |
| Crude streptomycin 240 p.p.m. | 302 | March 23[a]<br>March 31[b]<br>April 9[c]<br>April 20 | 2 | .007 | 2.92 |
| 20-80 copper dust | 300 | March 27[d]<br>April 1<br>April 7<br>April 21 | 2 | .007 | 2.92 |
| Check (untreated) average | | | | 2395 | 100 |
| 1 | 290 | --- | 93 | .320 | |
| 2 | 264 | --- | 42 | .159 | |

[a] 50 percent bloom
[b] 4 days past full bloom
[c] calyx stage
[d] full bloom

russetting. This latter quality of the streptomycin makes it a desirable substitute for copper if subsequent tests under varied orchard conditions show consistent results.

Since the streptomycin plot received only four applications of dust and was not adequately protected at certain critical times during March and April, some increase in blight was registered, as evidenced by the number of blight cuts made from May 1 to June 1, 1182 as against 7000 cuts for the check plot of 290 trees. Only 30 blight cuts were made on the copper plot up to June 1. However, this relationship is still very much in favor of streptomycin which gave 83.8 percent control of the blight up to June 1.

## Summary

Bentonite dust containing 240 p.p.m. of streptomycin base effected good control of pear blight when applied four times during March and April.

A copper-dust-treated plot developed light to severe fruit russetting, whereas the streptomycin-treated trees produced russet-free fruit.

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# A POSSIBLE SELECTIVE MEDIUM FOR THE OAK WILT FUNGUS[1]

Robert N. Campbell and David W. French

Endoconidiophora fagacearum Bretz, the cause of oak wilt, grows relatively slowly on most agar media, and when cultured in a mixed population of other fungi, is overgrown and cannot be identified. A selective medium, on which E. fagacearum would grow well enough to be recognizable in a mixture of other fungi, would be of value in various aspects of research with oak wilt. More than one hundred different media were tested for this purpose.

Oxgall has been found to inhibit the growth of many different kinds of fungi (1, 2, 3, 4). In the present work different concentrations of oxgall were added to diamalt, potato-dextrose, liquid malt, acorn extract, peptone dextrose, and maltose-casamino acids agars[2]. Peptone-dextrose agar with rose bengal and streptomycin (3) was also tested. These media, in petri dishes, were inoculated with a dilute conidial suspension of E. fagacearum alone and in combination with spores of such common molds as Aspergillus spp., Penicillium spp., Cladosporium sp., Trichoderma sp. and Rhizopus sp. The concentrations of spores were adjusted to yield from 10 to 25 colonies per plate. The media were then judged on the size and sporulation of the E. fagacearum, and on the degree to which growth and sporulation of the other molds were restricted. The best medium is the diamalt-oxgall medium, which contains 20 gm. Fleischmann's Dry Diamalt Syrup, 15 gm. Bacto-Oxgall (Difco), and 15 gm. agar per liter of water. Ascospores of E. fagacearum were found to be capable of germination and growth on this medium.

When the diamalt-oxgall plates are inoculated and incubated for five days at room temperature, E. fagacearum forms submerged compact colonies that average 2 to 3 mm. in diameter. The colonies can be seen easily by transmitted light. Typical endoconidia are produced on and beneath the surface of the agar, which facilitates positive microscopic identification of the fungus. At this time the only aerial mycelium consists of scattered, short conidiophores. After about nine days of incubation, there is a macroscopically visible tuft of hyphae.

Species of Aspergillus, Rhizopus, Penicillium, and Trichoderma generally form small, discrete colonies on media containing oxgall. Caution must be used to keep the number of colonies per plate low, otherwise some of the effect of the oxgall is lost.

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[1]Paper No. 3005. Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.

[2]Maltose-casamino acids formula supplied by Dr. H. L. Barnett, West Virginia University, in a personal communication, February 4, 1953.

## ADDITIONAL HOSTS FOR CHARCOAL ROT OF PLANTS IN INDIA

M. J. Thirumalachar, M. S. Pavgi, and J. N. Mishra

The charcoal rot disease incited by Macrophomina phaseoli (Maubl.) Ashby[1] is a major disease on several economic plants in sub-tropical and tropical regions. Young (1949) records as many as 284 hosts suceptible to this fungus. In India, charcoal rot disease was recorded on several hosts by Butler and Bisby (1931). Uppal et al. (1936) reported the hollow heart of sorghum in Bombay State as being caused by this fungus. Thirumalachar et al. (1953) reported charcoal rot of potatoes in Bihar and Uttar Pradesh in India and studied practical control measures. Virulent strains of this fungus were found to be selected out and multiplied on corn plants, thereby increasing the chances of infection of the potato crop, which often is planted in the same fields after harvest of corn.

(1) Charcoal Rot of Allium sativum: A severe storage rot of garlic was noticed in several storage godowns in Banaras, Uttar Pradesh, the damage sometimes being up to 50 percent. The diseased bulbs became hard and mummified, developing a black colour. In few cases, a soft rot resulted due to associated secondary organisms. Microscopic examination and cultural studies indicated that the chief causal organism was M. phaseoli. The mycelium regenerating from sclerotia grew vigorously in culture at 28° C. Wound inoculation of healthy bulbs with young vigorously growing hyphae from a 48-hours' old culture reproduced the disease within ten days. Smith et al. (1944) have previously reported charcoal rot of garlic in storage in Texas. As in the case of potato, the fungus infects the bulbs in the field during the growing season and symptoms become manifest during storage. There appears to be no secondary infection from diseased to healthy bulbs during the storage period.

(2) Foot Rot and Hollow Stem of Eleusine coracana Gaertn.: Eleusine coracana is an important millet crop in India and is a relatively hardy plant with few diseases reported on it. Near Pavapuri, Bihar, a large field of this crop was severely affected by a foot rot disease which caused severe damage, to the extent that harvesting of the crop was not economically feasible. The leaves were pale yellow and upturned, and the stem had lodged severely. The rootlets were killed and the plants could be uprooted with ease, duplicating symptoms caused by Helminthosporium nodosum on the same host. The collar portion had turned black, and careful examination showed that the stem at this region was hollow owing to the disintegration of pith which had been converted into snarls of fibres embedding sclerotial bodies of the fungus. In cultural studies the causal organism was identified as M. phaseoli. There is no previous record of this fungus on E. coracana.

(3) Charcoal Rot of Raphanus sativus: Late planted crops of radish in some fields in Bihar showed stunted growth and poor fleshy-root formation. On harvesting, many of the fleshy roots had turned partially or completely dark and the black discolouration was visible through the epidermis. Examination of the darkened portions revealed hyphae of M. phaseoli. In some cases the fungus girdled the plants near the collar region causing wilting of aerial shoots. Sclerotia of the fungus developed in the girdled portion which became greyish-white.

(4) Root Rots of Ricinus communis and Solanum nigrum: Considerable stunting of some castor plants was observed in a field near Patna, Bihar. Examination of root systems of affected plants showed that the rootlets had been killed, the dead tissue becoming white and bearing sclerotia of M. phaseoli. The tap root was thick and woody. No wilting was observed though the plants remained in a stunted condition until the end of the season.

A similar type of root infection was observed in Solanum nigrum also. The rootlets became greyish-white and bore the tiny black sclerotia of the fungus. The diseased plants, while showing no conspicuous macroscopic symptom except for the stunted condition, wilted during the hot noon period but regained normal turgidity during the night. Since no infection by Pseudomonas solanacearum was present, the wilting is attributed to killing of the rootlets by M. phaseoli. In a previous paper the senior author (1953 b) has shown that all strains of the charcoal rot fungus isolated from different hosts in India are capable of inciting charcoal rot of potato tubers on

[1] The fungus is not a Macrophomina and is being renamed. See Thirumulachar (1953).

artificial inoculation.

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## BRIEF NOTES ON PLANT DISEASES AND INJURIES

### A PROBABLE SOLUTION OF THE CALCIUM CYANAMIDE PROBLEM IN TOBACCO BED WEED CONTROL IN KENTUCKY[1]

By W. D. Valleau

In some parts of the country and in some parts of Kentucky, calcium cyanamide seems to give good weed control and tobacco plants grow well following treatment. In the Bluegrass area of Central Kentucky and in some other parts of the State results are erratic. Too frequently plants about 1/2 inch or smaller in diameter turn yellow during a dry period and if they do not die they are stunted, sometimes for several weeks, even in a wet season. Clumps of plants in other parts of the bed grow more normally but perhaps only one-half or one-third as fast as plants in a neighboring bed prepared some other way.

The American Cyanamid Company has prepared experimental beds in several counties in Central Kentucky the past few years in an attempt to solve the problem. This year, on invitation by company representatives, the writer availed himself of the opportunity of visiting some of these beds with the object of trying to interpret results. The cause of the difficulty and the means of preventing it seemed obvious to the writer and are here put on record.

Several things have been observed that are beneficial to tobacco plants in treated beds: 1) Watering heavily when the first small plants begin to yellow usually results in a rapid growth of healthy plants. 2) An application of phosphate fertilizer at the time of treatment has been helpful but plants still grow slowly but more uniformly in affected beds. 3) Turning under a heavy cover crop before treatment in high phosphate soils, or in heavily fertilized soils, has given excellent results but was thought not to be the answer because organic matter is not necessary to success in sandy soils. 4) Mulching the bed after treatment has given good plants.

On the theory that the cause of injury to small plants is excess ammonia (which is known to be a product of breakdown of cyanamide) the four helpful practices fit into a pattern. Excess ammonia (or urea which precedes it), could be leached by early heavy watering; or the ammonia could be gotten rid of by bringing about conditions for multiplication of a micro-organism that can use nitrogen in the ammonia form. Available phosphorus is known to stimulate growth of certain organisms if an energy source such as starch is present. In plant beds the addition of readily available phosphorus and the presence of a limited amount of undecomposed plant material has evidently resulted, in certain beds, in the disappearance of a part of the ammonia and a slight improvement in plant growth. In beds in normally high phosphate soil, or where fertilizers have been added, the addition of a large supply of an energy source (such as turning under a heavy crop of soybeans, a heavy crop of sweet fern, or other cover crop) in preparation for bed treatment, provides a basis for complete conversion of ammonia and the plants grow normally.

When a bed is mulched with organic matter an energy source is made available, at least at the soil surface, the temperature is probably higher under the mulch, and the soil is kept moist, thus making conditions satisfactory for microbial activity at any time when the temperature is favorable.

If this interpretation is correct our present program for wildfire (*Pseudomonas tabaci*) control, of using the same site year after year, sowing the bed to soybeans or some other fast-growing cover immediately after the crop is set, plowing the bed in the fall, and treating for weed control, should fit into the cyanamide weed control program perfectly.

KENTUCKY AGRICULTURAL EXPERIMENT STATION

[1]The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is reported by permission of the director.

### LETTUCE INJURY FROM 2, 4-D

By E. R. de Ong

Injury to lettuce has been found over extensive areas in the Salinas Valley, California, from the use of spray rigs that had previously been used for applying "low volatile esters" of 2, 4-D. Immediately following this use the tanks, nozzles, and boom were rinsed three times with cold water, one rinsing being alkaline. The lettuce is the heading type of one or more of the commercially grown types. The different fields varied in age from three to five weeks when sprayed.

Two of the spray rigs, after being rinsed, were used the next day for spraying lettuce with the insecticides DDT and Metacide, which had been dissolved in organic solvents and then emulsi-

fied. The third rig was not used until several days later for applying the same formula of insecticides. Every field of winter-seeded lettuce, where spray rigs with a 2, 4-D record had been used, was a complete loss. A spring-seeded field that received a late application of the same insecticide formula may show some marketable lettuce. Other lettuce fields that were sprayed with the same insecticide formula by rigs without a 2, 4-D record made a normal growth.

Symptoms of injury included twisted, distorted leaves, failure to form a solid head, and the formation of loose, peaked heads. Lettuce harvest that had begun in one field was stopped by the shipping inspector because of the increased tendency to break down from "slime mold". This term is applied to a form of soft rot especially noticeable in heads that have been injured by frost, downy mildew (Bremia lactucae), or other causes. Symptoms of injury to weeds in the treated fields included rounded or cupped leaves on lambs quarter (Chenopodium album) and pleated or fan-like leaves on mallow (Malva spp.).

Two factors are of especial importance in this case. The damage has been so extensive in its distribution that further restrictions are probable in the use of equipment with 2, 4-D history for any other purpose whatever. Second, additional emphasis has been laid on the persistence of 2, 4-D in tanks, booms, and nozzles and the danger that organic solvents in later formulations will take up the hormone compounds present in amounts very small but still sufficient to be dangerous to susceptible crops.

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## EARLY SEASON DISEASES OF GRAIN CROPS AND ALFALFA PRESENT AN UNUSUAL PICTURE IN SOUTHERN ILLINOIS

By G. H. Boewe

Corn Diseases: Stewart's disease (Bacterium stewartii) was killing 0.3 percent of the plants in an early planted field of corn in Alexander County on May 28. The corn was about knee high. This is our earliest record of the occurrence of the disease on field corn. Flea beetles, the vectors, have been more abundant in May than in the past 30 years or more. In a field of corn about 6 to 10 inches tall in Randolph County 1.2 percent of the plants were showing leaf symptoms but no plants were wilting.

Wheat Diseases: Leaf rust (Puccinia rubigo-vera tritici) is conspicuous by its absence. The first leaf rust (one pustule) was observed in Pulaski County on April 30. During the week of May 25, many wheat fields were examined in the southern three tiers of counties, and in most fields leaf rust prevalence was much less than 100 percent (average 40 percent) and severity was less than 1 percent. The extremely dry weather last summer and fall, the cool weather in April and most of May, and the use of resistant varieties may account for the light leaf rust development as moisture was plentiful this spring.

Stem rust (P. graminis) infection, observed first on May 26, occurred much earlier than usual this year. May 25 is our earliest record of its occurrence. In two fields examined stem rust was in the second and possibly the third generation. Prevalence and intensity ranged from 4 to 10 percent and a trace to 0.1 percent respectively. Stem rust was observed in all but one field examined.

Powdery mildew (Erysiphe graminis tritici) is causing considerable damage in a few scattered fields. Leaf spot, caused by Helminthosporium tritici-vulgaris Nisikado, is present on all plants and very severe on some varieties. Septoria leaf spot (S. tritici) is lighter than usual this year.

Rye Diseases: Leaf rust (P. rubigo-vera secalis) was present on rye examined as far north as central Illinois. In the southern part, it is present on all the plants and averaged 20 percent severity on all plants. Stem rust was present on from 9 to 12 percent of the culms in trace amounts. Some scab (Gibberella zeae) and considerable scald (Rhynchosporium secalis) was present in fields examined.

Oat Diseases: Stem rust was present in all winter-sown oat fields examined. Prevalence ranged from 21 to 64 percent (average 51.4 percent) and severity averaged 0.05 percent. Crown rust (P. coronata) was light on winter oats, with a maximum prevalence of 14 percent and intensity of 0.2 percent. Traces of crown rust were observed in spring-sown oats. Scab was present on 3 percent of the heads in winter oats.

Barley Diseases: Stem rust was found in trace amounts on 2 percent of the culms in one

field. Leaf rust (P. hordei) is very light, the maximum infection observed being 84 percent of the culms and 0.3 percent of the leaf area affected. Powdery mildew is very prevalent but not causing much damage. Lack of seed treatment was in evidence in one field where loose and covered smut (Ustilago spp.) caused an estimated loss of 15 percent and stripe blight (Helminthosporium gramineum) was present.

Alfalfa Diseases: An unusual epidemic of downy mildew (Peronospora trifoliorum) is present in the southern part of the State. Approximately 50 percent of the plants are diseased. In about 5 percent of the plants, all the tip leaves are diseased and severely dwarfed and deformed. Pseudopeziza [jonesii = Pyrenopeziza medicaginis], yellow blotch, and tar spot, Placosphaeria medicaginis, are present but in small amounts.

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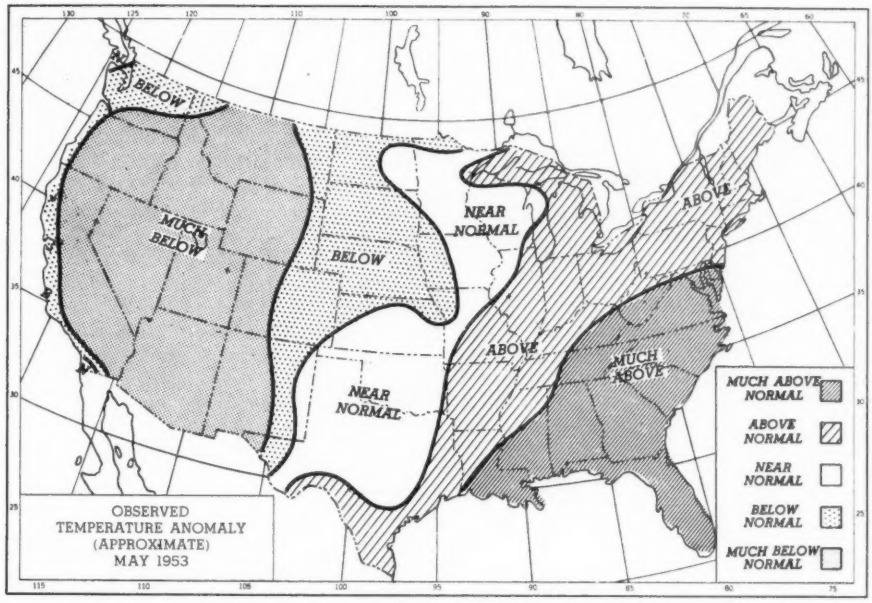
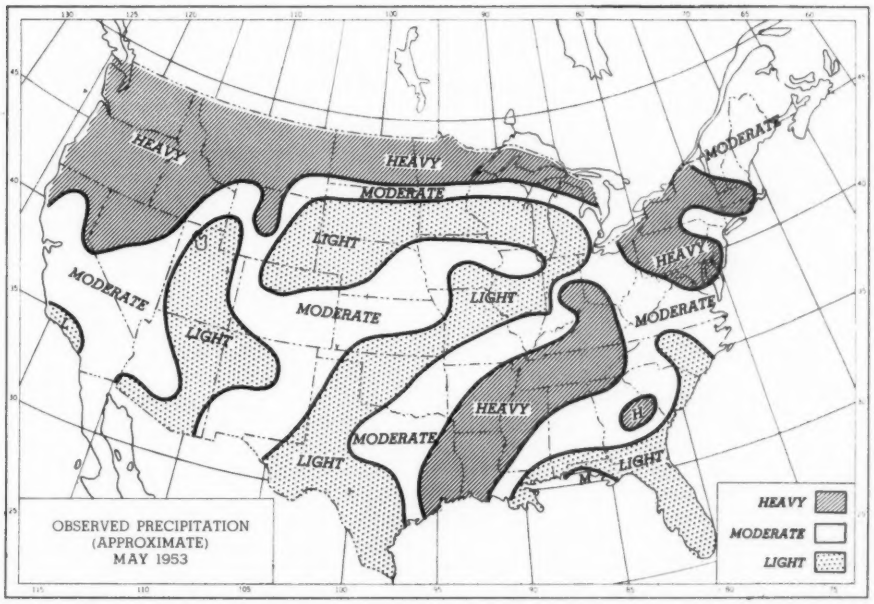
## A CORRECTION

On page 277 of the May 15 issue the notation "(Courtesy of M. A. Watson)" should be deleted from the title of the figure. The photograph is the author's own.




**The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.**